

## DIATOM FLORA OF BEAVER DAM CREEK, WASHINGTON COUNTY, UTAH, USA

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**ABSTRACT**—The diatom flora of Beaver Dam Creek, Washington County, Utah, was studied. The study area is in a warm Mojave Desert environment at an elevation between 810 and 850 m. A total of 99 taxa were identified from composite samples taken in the fall, winter, spring, and summer seasons. These taxa are all broadly distributed and no endemic species were encountered. Three new records for the state of Utah were identified: *Gomphonema erianeum* Skv. & Mayer, *Navicula elginensis* var. *lata* (M. Perag.) Patr., and *Nitzschia calida* Grun. The most important taxa throughout the study as determined by multiplying percent presence by average relative density (Important Species Index) were *Cymbella affinis* Kütz., *Epithemia sorex* Kütz., *Navicula veneta* Kütz., *Nitzschia palea* (Kütz.) W. Sm., and *Nitzschia microcephala* Grun.

*Key words:* Beaver Dam Creek, diatoms, desert streams.

The algal flora of the Intermountain West of North America is not well known despite the fact that numerous studies dealing with algal systems of waters in this region have been completed in recent years. These studies have examined streams, fresh water lakes, saline lakes, thermal springs, and terrestrial habitats (Sommerfeld et al. 1975, Stewart and Blinn 1976, Czarnecki and Blinn 1977, 1978, Blinn et al. 1980, Bush and Fisher 1981; for bibliographies see Rushforth and Merkley 1988, Metting 1991).

Algal floras of warm desert systems are especially poorly known. The present study was initiated to provide additional information on the diatom flora of a desert stream located in western North America. We examined the diatom communities of Beaver Dam Creek, a tributary of the Virgin River in southwestern Utah. This paper is intended as a baseline floristic and community study of the diatom communities present in this Mojave Desert stream.

We had three objectives in this study: (1) to identify all species of diatoms present in Beaver Dam Creek, (2) to document seasonal variation in the diatom communities of this stream, and (3) to compare diatom populations according to habitat type. Our study reports all diatom taxa present in this stream across four seasons of 1987-88. We studied populations in (1) riffle areas with erosional flow velocities, (2) deposi-

tional areas with slower flows, and (3) epiphytic habitats on the stems and leaves of aquatic vascular plant vegetation.

### SITE DESCRIPTION

Beaver Dam Creek at Lytle Ranch Preserve is located 37°10' North latitude and 114° West longitude in Washington County, Utah (Fig. 1). The stream occurs in our study area at an elevation of about 850 m at Lytle Ranch dropping to 810 m at Terry's Ranch. Our study sites are located along the wash near the ranch house at Lytle Ranch Preserve and near a smaller outbuilding at Terry's Ranch.

Beaver Dam Creek is a vigorous, braided perennial desert stream. It is important to the entire biota of the area since it is the main source of perennial water. The stream through the study area has formed a broad gravel flood plain due to frequent flooding. The stream occurs in bajada and alluvial fan materials derived from the Bull Valley, Pine Valley, and Santa Clara mountains (Welsh et al. 1987).

Beaver Dam Creek is fed by seeps, springs, and snowmelt primarily from the Pine Valley Mountains. This area is also characterized by flash floods caused by severe periodic thunderstorms in the summer and fall seasons. For instance, prior to the April 1985 collection, Beaver Dam Wash received 11 days of rain

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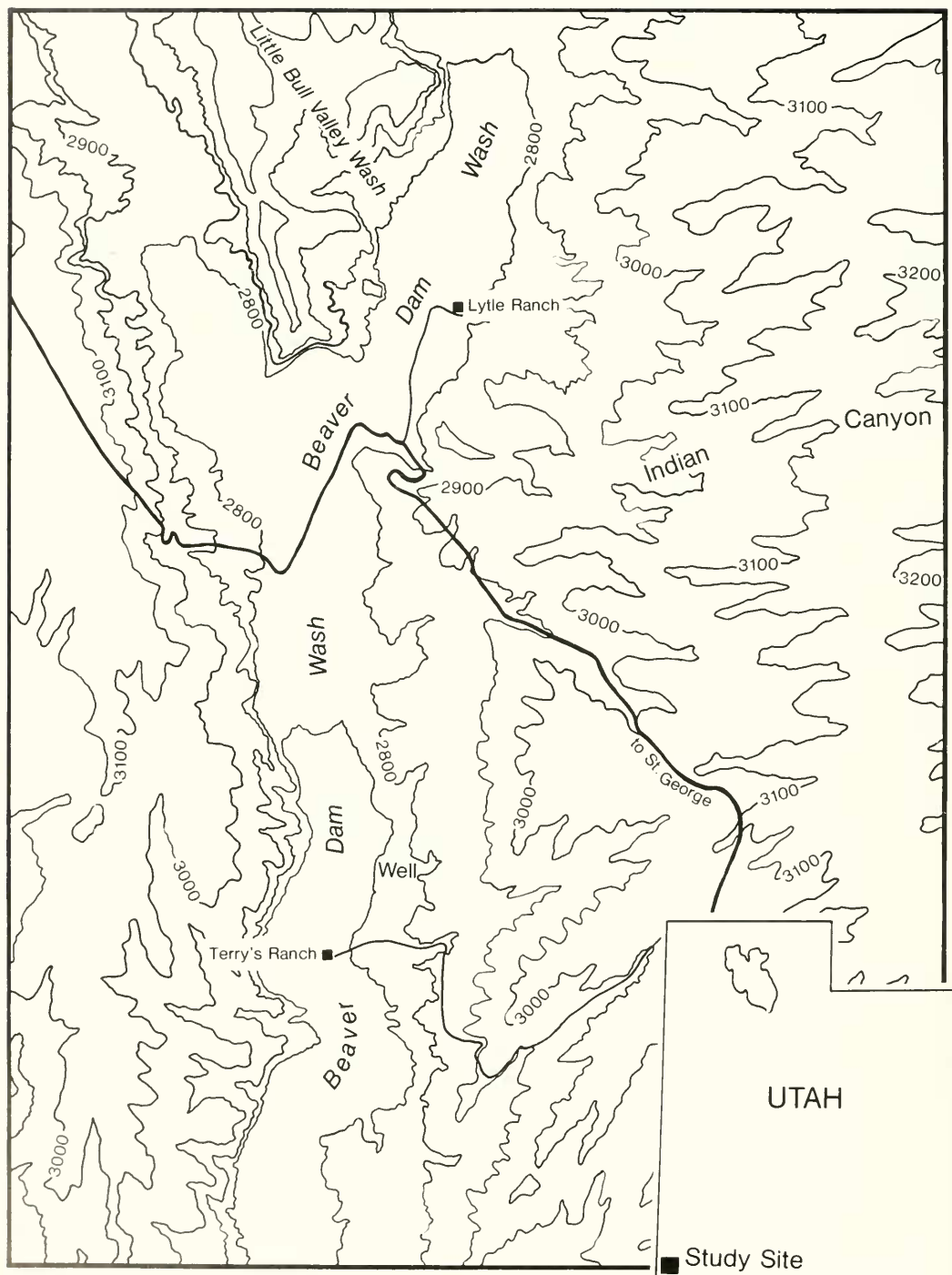


Fig. 1. Map of Beaver Dam Wash showing the location of collecting localities at Terry's Ranch and Lytle Ranch Preserve. Due to the meandering and changing nature of Beaver Dam Creek, the stream itself is not shown on this map.

producing moderate to severe flooding along the stream channel. This scoured the stream channel, removing large amounts of aquatic vegetation and causing channel relocation in some areas.

The gravel bar in Beaver Dam Creek is generally higher in the center than at the margins, causing the stream to meander over a wide area with frequent changes of channel during flooding (Welsh et al. 1987). The fall in elevation downstream is not constant. Gravel tends to pile up in steps that vary in length and height. This uneven granular substrate causes the stream to meander along the gravel bar and eventually to sink underground approximately four miles below the southernmost collection site (Welsh et al. 1987). The perennial stream reappears infrequently as seeps and springs lower in Beaver Dam Wash until merging with the Virgin River.

Climate in the study area varies considerably, not only diurnally and seasonally, but over longer periods of time. Winters are generally cool and dry, summers hot and dry. Maximum summertime temperatures have been recorded at 45.6 C. Rainfall averages less than 15 cm a year, although this is variable due to intense storms (Welsh et al. 1987).

The biota of our study area is exceptionally diverse. Mammals, birds, reptiles, amphibians, invertebrates, and a great variety of plants occur in Beaver Dam Wash (Welsh et al. 1987). The stream supports a diverse riparian habitat consisting of Fremont cottonwood (*Populus fremontii* Wats.), Arizona ash (*Fraxinus velutina* Torr.), black willow (*Salix gooddingii* Ball), seep willow (*Baccharis emoryi* Gray in Torr.), numerous forbes, grasses, and grasslike species (Welsh et al. 1987). Silty terraces occur immediately adjacent to the wash and have been historically used for cultivation. These areas are dominated by catclaw acacia (*Acacia greggii* Gray), paniculate rabbitbrush (*Chrysothamnus paniculatus* [Gray] Greene), *Ambrosia* species, and numerous others (Welsh et al. 1987). Adjacent uplands support Joshua tree forests (*Yucca brevifolia* Engelm.), creosote bush (*Larrea tridentata* [DC.] Cov.), prickly pear cactus (*Opuntia engelmannii* Engelm.), cholla cactus (*Opuntia basilaris* Engelm. and Bigel.), and numerous other xerophytic species (Welsh et al. 1987).

## METHODS

Water chemistry was sampled at the collection sites for February, April, and July 1988 using a portable Hach field water chemistry lab. Air temperature and water temperature, dissolved oxygen, hardness, alkalinity, and pH were measured.

Diatom collections were taken on 21 November 1987, 20 February 1988, 30 April 1988, and 6 July 1988 to document seasonal variations in diatom populations. Composite samples were collected from three habitat types. First, riffle areas with erosional flow rates were sampled by scraping algae from large stones in the creek bed. Second, slow water areas in the stream were sampled by obtaining sediments, rock scrapings, and visible attached algae. Finally, submerged sedge stems and leaves were scraped or collected at selected localities to study epiphytic assemblages.

Due to seasonal changes, it was not always possible to sample all three substrate types at both locations. A total of 19 samples were analyzed during the course of the study. Samples were stored at air temperature and returned to the laboratory at Brigham Young University for analysis.

Diatoms were cleared by boiling in nitric acid and potassium dichromate (St. Clair and Rushforth 1977). After rinsing, cleared frustules were suspended in distilled water and allowed to air dry on cover slips. Strewn mounts were prepared using Naphrax high-resolution resin. Representative slides were examined with Zeiss RA microscopes equipped with Nomarski optics and bright field illumination. An Olympus AD photomicrographic system was used to record each taxon. Strewn mounts have been placed in the collections at Brigham Young University.

A minimum of 500 valves was counted for each sample, and a percent relative density was calculated for each taxon (Kaczmarek and Rushforth 1983). An Important Species Index (ISI) for taxa present was calculated by multiplying the percent frequency of occurrence of a taxon in the samples by its overall average percent relative density in all samples (Ross and Rushforth 1980, Kaczmarek and Rushforth 1983). This method is useful since it considers both abundance and seasonal distribution of a taxon (Warner and Harper 1972). Species diversity for each sample was calculated using the

TABLE 1. Mean values for air temperature and water chemical parameters taken from collecting localities in Beaver Dam Creek, Washington County, Utah.

	February		April		July	
	Lytle	Terry's	Lytle	Terry's	Lytle	Terry's
Air temp. (C)	16.3	17.3	20.5	20.5	33.0	26.0
Water temp. (C)	14.5	17.5	16.8	16.8	24.3	22.3
Dissolved O <sub>2</sub> (mg/l)	9.5	10.0	9.0	9.0	7.7	7.0
Hardness (mg/l)	247.3	276.1	707.5	707.5	281.9	362.4
Alkalinity (mg/l)	195.6	207.1			201.3	224.3
pH	7.3	7.1	6.9	7.0	8.1	7.7

TABLE 2. Taxa present in samples collected from Beaver Dam Creek, 1987–88, listed with Important Species Index (ISI) values. When ISI is below 0.01, the species is listed as a trace (T).

Taxon	ISI	Lytle	Terry
<i>Achnanthes affinis</i> Grun.	1.92	1.8	2.6
<i>Achnanthes exigua</i> Grun.	0.03	0.1	0.1
<i>Achnanthes lanceolata</i> (Bréb.) Grun.	2.51	3.8	1.1
<i>Achnanthes minutissima</i> Kütz.	1.92	3.4	1.3
<i>Amphora libyca</i> Ehr.	0.10	0.4	0.1
<i>Amphora pediculus</i> (Kütz.) Grun.	1.76	2.5	1.1
<i>Amphora veneta</i> Kütz.	0.13	0.6	0.1
<i>Caloneis bacillum</i> (Grun.) Cl.	T		
<i>Caloneis silicula</i> (Ehr.) Cleve	T		
<i>Cocconeis pediculus</i> Ehr.	0.04	0.1	0.1
<i>Cocconeis placentula</i> var. <i>euglypta</i> (Ehr.) Cleve	1.07	3.1	0.8
<i>Cocconeis placentula</i> var. <i>lineata</i> (Ehr.) V.H.	1.22	1.4	1.1
<i>Cyclostephanos incisitatus</i> (H. & H.) Ther., Stoerm. & Hak.	T		
<i>Cyclotella meneghiniana</i> Kütz.	0.72	1.0	0.5
<i>Cymbella affinis</i> Kütz.	17.57	23.4	13.2
<i>Cymbella mexicana</i> (Ehr.) Cl.	T		
<i>Cymbella microcephala</i> Grun.	0.58	1.2	0.5
<i>Cymbella silesiaca</i> Bleisch	0.16	0.4	0.1
<i>Cymbella tumida</i> (Bréb. ex Kütz.) V.H.	T		
<i>Denticula elegans</i> Grun.	1.44	2.5	0.4
<i>Denticula elegans</i> f. <i>valida</i> Pedic.	T		
<i>Diatoma vulgare</i> Bory	0.84	1.7	0.5
<i>Diatoma vulgare</i> var. <i>breve</i> Grun.	0.11	0.5	0.1
<i>Epithemia adnata</i> var. <i>proboscidea</i> (Kütz.) Hend.	0.07	0.1	0.3
<i>Epithemia sorex</i> Kütz.	13.25	1.8	35.9
<i>Epithemia turgida</i> (Ehr.) Kütz.	T		
<i>Fragilaria construens</i> (Ehr.) Grun.	0.21	0.5	0.2
<i>Fragilaria construens</i> f. <i>venter</i> (Ehr.) Hust.	0.50	0.5	0.8
<i>Fragilaria pinnata</i> Ehr.	0.14	0.2	0.3
<i>Fragilaria vaucheriae</i> (Kütz.) Peters.	2.21	1.1	3.0
<i>Gomphoncis ericse</i> (Grun.) Skv. & Meyer	0.02	0.1	0.1
<i>Gomphoncis olivacea</i> (Horne.) Dawson	0.27	0.7	0.2
<i>Gomphonema acuminatum</i> Ehr.	T		
<i>Gomphonema angustum</i> Agardh	0.51	0.8	0.4
<i>Gomphonema clavatum</i> (Ehr.)	0.06	0.2	0.2
<i>Gomphonema grunowii</i> Patr.	0.08	0.3	0.2
<i>Gomphonema parvulum</i> (Kütz.) Kütz.	1.89	2.1	0.2
<i>Gomphonema pseudoangur</i> L.-Bert.	1.32	1.6	1.5
<i>Gomphonema truncatum</i> Ehr.	T		
<i>Gyrosigma noduliferum</i> (Grun.) G. West	T		
<i>Hantzschia amphioxys</i> (Ehr.) Grun.	T		
<i>Melosira varians</i> Ag.	0.06	0.3	0.1
<i>Meridion circulare</i> (Grev.) Ag.	T		
<i>Navicula abiskoensis</i> Hust.	T		
<i>Navicula atomus</i> var. <i>permutis</i> (Hust.) L.-Bert.	0.08	0.2	0.1
<i>Navicula bacillum</i> Ehr.	0.09	0.2	0.2

TABLE 2. Continued.

<i>Navicula capitatoradiata</i> Germain	1.99	2.7	2.0
<i>Navicula cincta</i> (Ehr.) Ralfs	0.17	0.5	0.1
<i>Navicula constans</i> var. <i>symmetrica</i> Hust.	T		
<i>Navicula cuspidata</i> Kütz.	T		
<i>Navicula elginensis</i> var. <i>lata</i> (M. Perag.) Patr.	0.06	0.2	0.1
<i>Navicula gregaria</i> Donkin	0.16	0.5	0.1
<i>Navicula menisculus</i> Schumann	T		
<i>Navicula minuscula</i> var. <i>muralis</i> (Grun.) L.-Bert	0.06	0.3	0.1
<i>Navicula pupula</i> Kütz.	0.16	0.4	0.2
<i>Navicula radiosa</i> Kütz.	0.19	0.3	0.3
<i>Navicula tripunctata</i> (O.F. Müll.) Bory	0.12	0.5	0.1
<i>Navicula tripunctata</i> var. <i>schizonemoides</i> (V.H.) Patr.	0.10	0.4	0.1
<i>Navicula trivialis</i> L.-Bert.	0.28	0.6	0.2
<i>Navicula veneta</i> Kütz.	8.78	9.0	5.6
<i>Neidium affine</i> (Ehr.) Pfitz.	T	0.1	
<i>Neidium dubium</i> (Ehr.) Cl.	T		
<i>Nitzschia acicularis</i> (Kütz.) W.Sm.	0.02	0.1	0.1
<i>Nitzschia amphibia</i> Grun.	1.51	2.4	0.4
<i>Nitzschia calida</i> Grun.	0.02	2.0	
<i>Nitzschia communis</i> Rabh.	0.30	0.9	5.9
<i>Nitzschia constricta</i> (Kütz.) Ralfs	0.19	0.4	0.3
<i>Nitzschia dissipata</i> (Kütz.) Grun.	1.90	3.9	0.4
<i>Nitzschia fonticola</i> Grun.	0.58	1.1	0.4
<i>Nitzschia frustulum</i> (Kütz.) Grun.	0.01	0.1	
<i>Nitzschia hantzschiana</i> Rabh.	0.20	0.2	0.1
<i>Nitzschia inconspicua</i> Grun.	0.65	1.4	0.2
<i>Nitzschia linearis</i> (Ag.) W. Sm.	T		
<i>Nitzschia microcephala</i> Grun.	5.44	4.7	6.3
<i>Nitzschia palea</i> (Kütz.) W. Sm.	5.76	8.7	2.4
<i>Nitzschia sigmoides</i> (Nitz.) W. Sm.	0.01	0.1	0.1
<i>Nitzschia subtilis</i> Grun.	T		
<i>Pinnularia appendiculata</i> (Ag.) Cl.	T	0.1	
<i>Pleurosira delicatulum</i> W. Sm.	0.02		0.2
<i>Pleurosira laevis</i> (Ehr.) Compere	T		
<i>Reimeria sinuata</i> (Greg.) Kociolek & Stoermer	T	0.1	
<i>Rhoicosphenia curvata</i> (Kütz.) Grun.	2.73	1.4	4.9
<i>Rhopalodia brebissonii</i> Krammer	T		
<i>Rhopalodia gibba</i> (Ehr.) O. Müll.	T		
<i>Rhopalodia gibba</i> var. <i>ventricosa</i> (Kütz.) Perag. & Perag.	0.01	0.1	
<i>Rhopalodia gibberula</i> (Ehr.) O. Müll.	0.03	0.2	0.1
<i>Stauroneis smithii</i> Grun.	T	0.1	
<i>Stenopterobia intermedia</i> (Lewis) V.H.	T		
<i>Stephanodiscus hantzschii</i> Grun.	0.02		0.1
<i>Surirella angusta</i> Kütz.	0.06	0.2	0.1
<i>Surirella minuta</i> Bréb.	T		
<i>Surirella ovalis</i> Bréb.	T		
<i>Synedra acus</i> Kütz.	T		
<i>Synedra fasciculata</i> var. <i>truncata</i> (Grev.) Patr.	T		
<i>Synedra radians</i> Kütz.	0.01	0.1	0.1
<i>Synedra rumpens</i> var. <i>meneghiniana</i> Grun.	0.11	0.1	0.3
<i>Synedra ulna</i> (Nitz.) Ehr.	0.40	0.7	0.5
<i>Synedra ulna</i> var. <i>contracta</i> Oestr.	0.20	0.3	0.3

Shannon-Wiener diversity index (Shannon and Weaver 1949, Zar 1986).

Similarity indices were calculated for all pairs of samples following Ruzicka (1958). Cluster analyses based on Ruzicka's indices using unweighted pair-group techniques (UPGMA) were then performed (Sneath and Sokal 1973). This method computes the average similarity of each site to every other site using arithmetic

averages. It is widely used and has been found to introduce less distortion than other methods (Kaesler and Cairns 1972).

RESULTS AND DISCUSSION

Water chemistry did not vary significantly according to collection locality (Table 1). Stream temperature increased somewhat during the

summer months, but it is noteworthy that temperature variations in the stream were relatively small. The stream is circumneutral to slightly alkaline.

A total of 99 diatom taxa in 24 genera were observed in our collections. Three new records for the state of Utah were noted: *Gomphonopsis ericense* (Grun.) Skv. & Meyer, *Navicula elginensis* var. *lata* (M. Perag.) Patr., and *Nitzschia calida* Grun. Taxa are illustrated and described in Yearsley (1988). Nomenclature followed in Yearsley (1988) was similar to that used historically by researchers in our laboratory for comparative purposes (Rushforth and Merkle 1988). Diatom taxonomy in this paper is based primarily on the recent texts of Krammer and Lange-Bertalot (1986, 1988, 1991), although other references were consulted and sometimes followed. We did not follow the numerous generic changes proposed in Round et al. (1990) due to the controversy over many of their recommendations.

Eighteen taxa in Beaver Dam Creek had an Important Species Index value greater than 1.0 (Table 2). The most important taxa in the overall study with ISIs above 5.0 were *Cymbella affinis* (ISI = 17.57), *Epithemia sorex* (13.25), *Navicula veneta* (8.78), *Nitzschia palea* (5.76), and *Nitzschia microcephala* (5.44). Taxa with ISIs greater than 1.0 included *Rhoicosphenia curvata* (2.73), *Achnanthes lanceolata* (2.51), *Fragilaria vaucheriae* (2.21), *Navicula capitatoradiata* (1.99), *Achnanthes affinis* (1.92), *Achnanthes minutissima* (1.92), *Nitzschia dissipata* (1.90), *Gomphonema parvulum* (1.89), *Nitzschia amphibia* (1.51), *Denticula elegans* (1.44), *Gomphonema pseudoangur* (1.32), *Cocconeis placentula* var. *lineata* (1.22), and *Cocconeis placentula* var. *euglypta* (1.07). All of these taxa are cosmopolitan and found in a variety of habitats.

In comparing the diatom assemblage from Beaver Dam Creek with the floras of streams of other arid regions, we noticed a striking similarity. The important taxa overlapped in all of the studies even though the streams varied in terms of their flow rate and climatic regime. Furthermore, each system was dominated by cosmopolitan species. Our preliminary data indicate that a diatom flora unique to desert streams does not exist. Further research to substantiate this conclusion is necessary; some evidence is given below.

Blinn et al. (1980) considered substrate col-

onization in Oak Creek, Arizona. They reported 12 important taxa which, in order of decreasing abundance, were: *Nitzschia frustulum*, *Epithemia sorex*, *Cocconeis placentula* var. *euglypta*, *Achnanthes minutissima*, *Navicula cryptocephala*, *Navicula veneta* (as *N. cryptocephala* var. *veneta*), *Nitzschia dissipata*, *Achnanthes lanceolata*, *Cymbella affinis*, *Fragilaria construens*, *Navicula decussis*, and *Synedra ulna*. These diatoms accounted for 90% or more of the total algal population on newly introduced material in their study. Eight of these taxa were also important in our stream, having ISI values above 1.0.

Johnson et al. (1975) conducted further study on the diatom flora of Oak Creek, Arizona. They reported 41 diatom taxa, of which 25 are common to our study area. *Cymbella affinis*, *Epithemia sorex*, and *Nitzschia palea* were reported as common or abundant. This compares favorably with the results of our study since these three were among the most common diatoms in Beaver Dam Creek.

Rushforth et al. (1976) examined the algal flora of Freshwater Wash, Arches National Park, in southeastern Utah. Their study documented 57 diatom taxa, 29 of which were also observed in Beaver Dam Creek. *Achnanthes minutissima*, *Cymbella affinis*, *Denticula elegans*, *Gomphonema acuminatum*, *Navicula radiosa*, *Nitzschia linearis*, *Nitzschia palea*, *Rhoicosphenia curvata*, and five other species not present in Beaver Dam Creek were the most abundant taxa in Freshwater Wash.

In their analysis of Sycamore Creek, Arizona, Fisher et al. (1982) reported that diatoms made up 77% of the total algal mass, with *Achnanthes exigua*, *Gomphonema parvulum*, and *Navicula pupula* being the most important taxa. These taxa were present in Beaver Dam Creek but in lower numbers. *Gomphonema parvulum* was the most abundant of the three in our samples.

The flora of Beaver Dam Creek is also similar to that of other streams of western North America draining more mesic regions. Cushing and Rushforth (1984) in a study of the Salmon River, Idaho, identified 145 diatom species, 48 of which were among the 99 taxa found in Beaver Dam Creek. Half of their important species (9 of 18) were also among the important species in Beaver Dam Creek, several with similar importance values.

Preliminary research also indicates that a flora similar to that found in North American

hardwater streams exists elsewhere. Squires and Saoud (1986) reported nine taxa from the Damour River, Lebanon, with Importance Species Index values above 1.0. Six of these also were important in Beaver Dam Creek. In the Damour River study *Achnanthes minutissima* was the most important taxon with an ISI value of 44.4, followed by *Nitzschia dissipata* (5.12), *Cymbella microcephala* (3.63), and *Cymbella affinis* (2.62).

Shannon-Wiener diversity values for all 24 samples ranged between 1.95 and 4.59. Diversity did not show any clear trends with regard to season or substrate type. The overall mean for the indices was 3.42, the median value being 3.57. These values are relatively high and indicative of unpolluted water.

Our collections did not cluster well on the basis of habitat type or season. However, there was a tendency for stands to cluster on the basis of the Terry's Ranch versus Lytle Ranch Preserve collecting localities (Fig. 2). The uppermost cluster consists of samples from Terry's Ranch, while the second cluster contains samples from the Lytle Ranch Preserve. The third cluster has a mix of all sites, substrates, and seasons. The fall depositional sample from the Lytle Ranch Preserve is an outlier.

The reasons for the clustering by site seen in the top half of the cluster are unclear. Water chemistry and temperature did not vary greatly between the sites during the year (Table 1). Likewise, insolation is approximately the same for both sections of the creek. Stream velocities, however, appear to be different. The creek at Lytle Ranch Preserve is generally slower, shallower (<15 cm), wider, and more meandering than the stream at Terry's Ranch where pools may reach depths of nearly one meter.

The cluster shows a number of samples that paired by date of collection (Fig. 2). However, seasonality was very weak. The absence of seasonal changes is probably attributable to one or two factors. First, temperature changes throughout the year are minor, and changes in photoperiod alone are not enough to drive succession. Second, storm events scour the creek bed occasionally and may keep the diatom assemblage in an early successional stage.

The habitat types sampled did not cluster separately, indicating they are fairly similar. Because of scouring events, the depositional areas initially sampled often had all sediments removed at later sampling dates and so consist

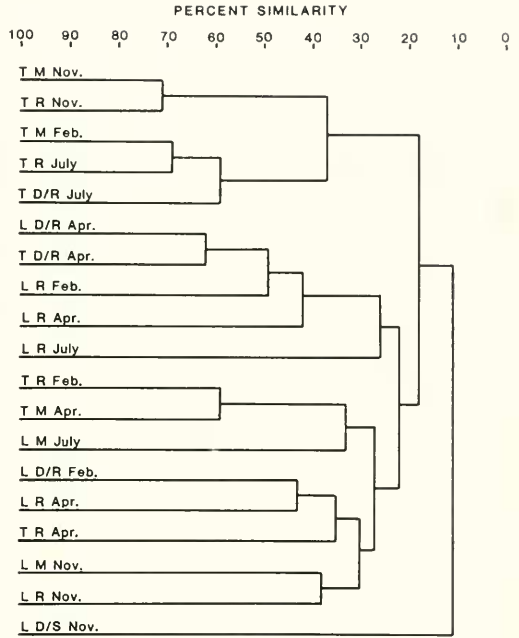


Fig. 2. Cluster diagram of 19 samples collected from Beaver Dam Creek. T = Terry's Ranch, L = Lytle's Ranch Preserve, M = macrophytic vegetation (sedges), R = riffle, D/S = depositional area, sediments, D/R = depositional area, rock scrapings.

of rock scrapings, just as in the riffle areas. The one sample that consisted of sediment only (Lytle Ranch, November 1987, depositional area) clustered separately from all other samples (see bottom line of cluster, Fig. 2).

In summary, the diatom assemblages observed in Beaver Dam Creek consisted of cosmopolitan species common to other hardwater rivers. Seasonality was minimal, as were the effects of habitat type.

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